

ILC MAGNET DESIGN GUIDELINES FOR ALL ROOM TEMPERATURE MAGNETS

These guidelines to be followed by all magnet engineers designing magnets for any part of the ILC, for the RDR or for costing purposes

First draft written by Cherrill Spencer, SLAC, 18th April 2006

In order to have common operating conditions throughout the ILC, to minimize the number of conductor sizes that will need to be stocked for spares and to ensure reliable magnets by staying within well-recognized limits on magnet parameters, the following guidelines have been issued by the ILC Magnet Systems Group.

Hollow Copper Conductors

Quality of Copper

The electrical conductivity of the copper will be at least 100% IACS.

The composition of the copper will be Cu minimum 99.99%, O maximum 0.0005 %.

The name of this alloy in various countries under various standards is:

Germany, DIN 1787 OF-Cu

U.K., B.S. 6017:1981 Cu-OF

France, NF A53-100 Cu-c1

U.S.A., ASTM C 10200 OF

EN CW 008A

Preparation of the copper

The copper will be bright annealed to a deadsoft temper (per, for example ASTM B188), free of surface defects or damage, nicks, cuts and scratches.

Shape of conductor

Will have a square outside with rounded corners and a round hole centered within specified tolerance.

Sizes of conductor

Almost all of the room temperature magnets' coils can be made from one of only three sizes of copper conductor. The 3 sizes quoted here can carry currents from ~20 to ~600 amps with suitable water circuit lengths. Coils carrying under 20 amps can use solid copper wire.. Over 600 amps will need special conductor size.

Smallest size: 4.76 mm outside, 3.18 mm diameter hole, 1mm corner radius

Medium size: 6.48 mm outside, 3.18 mm diameter hole, 1 mm corner radius

Large size: 8.64 mm outside, 4.66 mm diameter hole, 1.5 mm corner radius

The two major copper conductor vendors have tools for these exact sizes already. All water-cooled magnet designs should use one of these 3 sizes.

Minimum lengths of conductor to order

The minimum length of segments of copper conductor ordered must be long enough to wind a single water circuit with no internal brazed joints.

Incoming Low Conductivity Cooling Water (LCW) Temperature

Assume the temperature of the incoming LCW is 35° C.

Maximum increase in LCW temperature as passes though a water circuit in a coil

25° C. Need to keep the actual LCW temperature below 60° C to be well below epoxy glass transition temperatures, and to not shorten insulation lifetime too much.

Differential Water Pressure

Assume it is typically 7 kG/cm² (100psi), but if not enough cooling can be achieved with 7 kG/cm², then assume there will be a high pressure LCW system with 14 kG/cm² available, but must meet the water velocity limit quoted below.

Velocity of LCW in any water circuit

The LCW flow must be in the turbulent region but its velocity must be less than 4 meters per second (to minimize the wearing away of copper by too vigorous water flow).

Number of cooling circuits per magnet

Enough to satisfy the delta temperature limit and water velocity limit, but not more than needed so as to keep down the number of water hoses and water fittings, which are a major source of magnet failures.

Steel Core Details

Laminated or solid steel cores?

We should have a discussion about the types of cores we could design and the type and quality of the steel to be used. We could say that any magnet style which has less than 50 (100? 200?) magnets to be made should have solid cores and any magnet style with more than 50 (100? 200?) should be made from laminations.

For solid steel should be a low carbon steel C1010 or C1008 or C1006. We should all use the same B-H curves in our magnet modeling programs for each steel type.

For laminated cores we need to decide whether just one thickness will do and the type(s) of steel.

Allowing space for beam pipes

We have asked the area beam physicists to give us the aperture (bore diameter or gap) of each of their magnet styles. Can we be sure they have remembered to leave room for a beampipe of, say, 1.5mm wall thickness? Maybe we should ask them to quote us a beam-stay-clear value for each style (we don't ask for it on our magnet parameter input list yet) and then we can calculate the physical aperture that will allow room for the beampipe and give them their beam-stay-clear value. We would need to consult with the Vacuum Systems group to ascertain the beampipe thickness in each beamline.

Margins to add for magnet integrated strengths and power supplies maximum current

If a beam physicist tells us the maximum integrated strength required on a magnet style is X T-m (for example) shall we design it to just reach X (e.g. the delta T of the LCW is 25° C when it runs at X)? When we specify the power supply shall we have it provide just the maximum current or shall we make it S percent stronger? How do we make sure the beam physicist hasn't already added P% to the strength because they don't trust the magnet designers! Then if we add another P% we are spending extra fabrication cost and providing un-needed capacity.

There are other topics that ought to be added to this set of guidelines. This is a list to get us started.